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# Experimental Investigation of Matched-Field Processing in a Wedgelike Shallow-Water Environment

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**Abstract:** The phenomenon of horizontal "refraction" is studied using vertical-line-array source-tow data recorded in a steep wedgelike environment near San Clemente Island, California. Evidence for horizontal "refraction" occurs in multi-frequency signal measurements plotted as a function of source range. Matched-field localization errors appear when the effect is ignored in replicas. The inclusion of modeled horizontal refraction effects in a matched-field processor is also investigated.

## INTRODUCTION

Underwater acoustic propagation in shallow-water wedgelike environments will experience "bending" out of the vertical plane containing the source and receiver[1-2]. Consequently, the time for the energy to travel from the source to the receiver will be altered, or some paths may miss the receiver altogether. Localization estimates from array processors will be in error if this horizontal multipath propagation is ignored. This phenomenon is investigated experimentally via the analysis of vertical-line-array (VLA) source-tow data recorded in a steep wedgelike environment during the fourth Shallow Water evaluation cell Experiment (SWellEX-4). The objective of this study is (1) to observe the horizontal "refraction" effects via an examination of the matched-field localization errors resulting from a neglect of that phenomenon, and (2) to study the feasibility of including modeled horizontal refraction effects into the matched-field processor to enhance localization performance.

## SWellEX-4

SWellEX-4 took place in March 1995 offshore San Clemente Island, an area characterized by steep bottom slopes (as high as 6° to 7°). A 64-phone VLA was suspended beneath the research platform FLIP in approximately 218 m of water. Source tows, transmitting 10 narrowband frequency tonals from 52 to 187 Hz at 15-Hz increments, were performed in the vicinity of the VLA by the CFAV Endeavour. The source tow track considered in this analysis is shown in Fig. 1, along with the bathymetry of the region and the location of the VLA (at the origin). Nineteen elements of the original 64-element VLA were used in this analysis, with a spacing of 5.626 m and an aperture of 101.25 m positioned in the upper half of the water column.

## MULTI-FREQUENCY SIGNAL ANALYSIS

Possible evidence for the presence of horizontal "refraction" is provided via an examination of multi-frequency single-phone signal power versus time (or source range) over the source tow interval. Figure 2 presents such an analysis for the 67, 82, 97, and 112 Hz tonals on channel 10. Note that the field is "stretched" as frequency is increased. The diagonal line identifies an apparent modal cutoff point which occurs at earlier times as frequency increases. These results are in agreement with theoretical observations for wedge environments[1-2]. Modal caustic lines, hyperbolas defining the regions in which particular modes propagate, tend to flatten toward straight lines parallel to the wedge apex as frequency increases. This reduction in the degree of hor-



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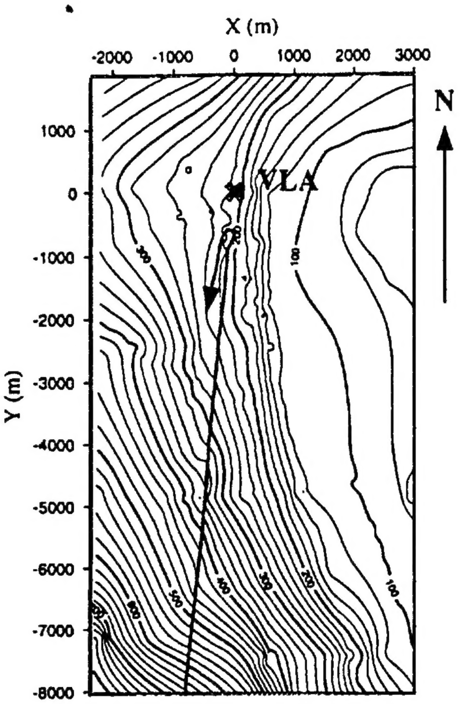


FIGURE 1. SWellEX-4 environment, VLA location, and source-tow track analysed.

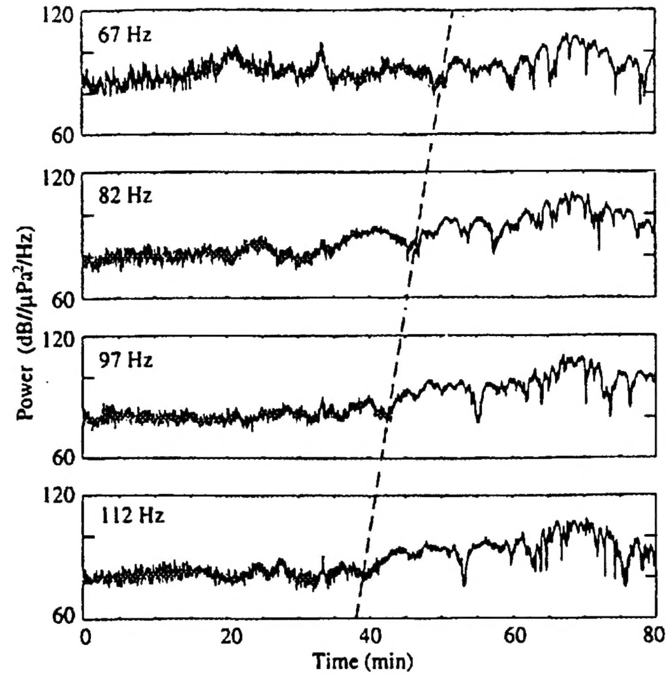


FIGURE 2. Single-phone (channel 10) power at 67, 82, 97 and 112 Hz versus time (or source range) over source-tow interval.

izontal "bending" results in the moving of modal cutoff points to larger ranges, as observed in Fig. 2.

## MATCHED-FIELD LOCALIZATION ERRORS

Prior to performing a matched-field analysis, inversions for optimal geoacoustic parameters and array configuration parameters were performed at short range so that mismatch in these parameters would not be misinterpreted as a horizontal "refraction" effect. The optimized array configuration possessed an array tilt component of 4.2° in the direction away from the source, with a top phone depth of 20.625 m. Modelling the bottom as a simple fluid half-space, an optimal compressional sound speed in the bottom was determined to be 1586.0 m/s.

Matched-field range and depth estimates obtained using two-dimensional replica models (no "bending") were observed to diverge from true values as the source range increased. This implies that significant horizontal "refraction" may be present in the data. The feasibility of including horizontal refraction effects into the matched-field processor, via the use of a three-dimensional Gaussian Beam code, was also investigated.

## ACKNOWLEDGEMENTS

This work was supported by ONR/SPAWARSYSCEN San Diego. Richard Bachman of SSC San Diego provided a reconstructed bathymetric grid for the SWellEX-4 environment. Ross Chapman and Ronald Kessel of the University of Victoria provided the bathymetry data and many useful insights into the analysis.

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2. Glegg, S. A. L. and Yoon, J. R., *J. Acous. Soc. Am.*, **87**, 101-105 (1990).

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The phenomenon of horizontal "refraction" is studied using vertical-line-array source-tow data recorded in a steep wedgelike environment near San Clemente Island, California. Evidence for horizontal "refraction" occurs in multi-frequency signal measurements plotted as a function of source range. Matched-field localization errors appear when the effect is ignored in replicas. The inclusion of modeled horizontal refraction effects in a matched-field processor is also investigated.

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